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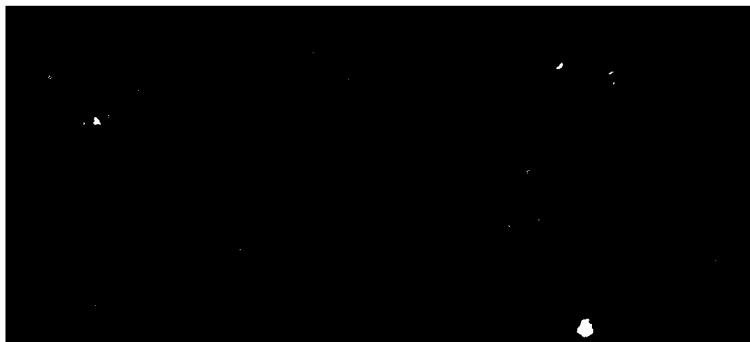
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PREFACE

The work described in this report was authorized under task 1L162622A554-3, Smoke/Obscurant Technology. The study was conducted in March 1979.

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OPTICAL COATINGS AS ANTIARMOR WEAPONS - A REVIEW

I. BACKGROUND.

This publication is essentially the information contained in a fact sheet prepared by the author in March 1979 in response to an inquiry from the Commander of the Infantry School, Major General Livsey, to the Commander of US Armament Research and Development Command (ARRADCOM), Major General Bennett L. Lewis. The fact sheet was subsequently briefed in May 1979 to Dr. J. Sparazza, Director of Army Materiel Systems Analysis Activity (AMSAA), who also has a keen interest in this subject. More recently there has been renewed interest in the subject and requests for the fact sheet from a number of sources. This special report was prepared to provide a wider distribution of this study than was possible with the fact sheet.

The use of aerosols to degrade the target acquisition optics of armored vehicles is an intriguing concept. Over the last several years it has been proposed on several occasions. Previous theoretical and experimental studies have been conducted to assess various aspects of the concept. The results of those studies are summarized here.

II. DISCUSSION.

Six different studies have been uncovered which address the optical-coating concept. The content of these studies is summarized in the appendix. These studies examined, in various degrees, the four main aspects which must be addressed in determining the feasibility of the optical-coating concept. The aspects are:

A. The Selection of a Candidate Coating.

A variety of materials was examined. At least two pigments were found which when applied in the laboratory produced acceptable obscuration. It was found, however, that at least 80% of the optics' surface area had to be coated for even the best coating to be effective.

B. Assessment of the Feasibility of Obtaining a True Aerosol Which Will Coat Optics.

This issue is only indirectly addressed in most of the studies. In general, it is avoided by recommending a larger particle spray or rain which falls on or is directed at the optics. These larger droplets have a sufficiently high impaction efficiency to make them attractive. Unfortunately, this need for large droplets, direct hit or dispenser proximity to the optics extracts a significant toll when expenditure requirements are calculated.

C. The Logistics Burden Imposed by Such Systems.

The US Army Mobility Equipment Research and Development Command (MERADCOM) and the Director of Defense Research and Engineering (DDRE)

studies addressed the logistics aspects of the concept and found no advantage over using high explosives (HE) to produce the same results.

D. Countermeasures.

None of the studies seriously addressed countermeasures. The US Army Training and Doctrine Command (TRADOC) comments, however, stated that ease of countermeasure was a principal drawback in considering such systems.

In order for an optical coating concept to be attractive, it appears that the active material must be delivered as a true aerosol. Unfortunately, when particle size is made small enough to remain airborne (~ 25 micrometers or less in diameter) impaction efficiency is markedly reduced. Some simple calculations will demonstrate this fact.

When an obstacle is introduced into a flowing aerosol, the smallest particles are able to flow past the obstacle with the airflow, whereas the larger particles, because of their greater inertia, can change their direction with respect to the air and be intercepted by the obstacle. This phenomenon is referred to as impaction. The impaction efficiency of spherical particles on an isolated disc transverse to flow was measured by May and Clifford.* Using their data, the expected impaction efficiency for spherical aerosol against an 8-inch-diameter lens is computed in the figure for various tank speeds.

*K. R. May and R. Clifford, The Impaction of Aerosol Particles on Cylinders, Spheres, Ribbons, and Discs. Ann. Occup. Hyg., 10,83 (1967).

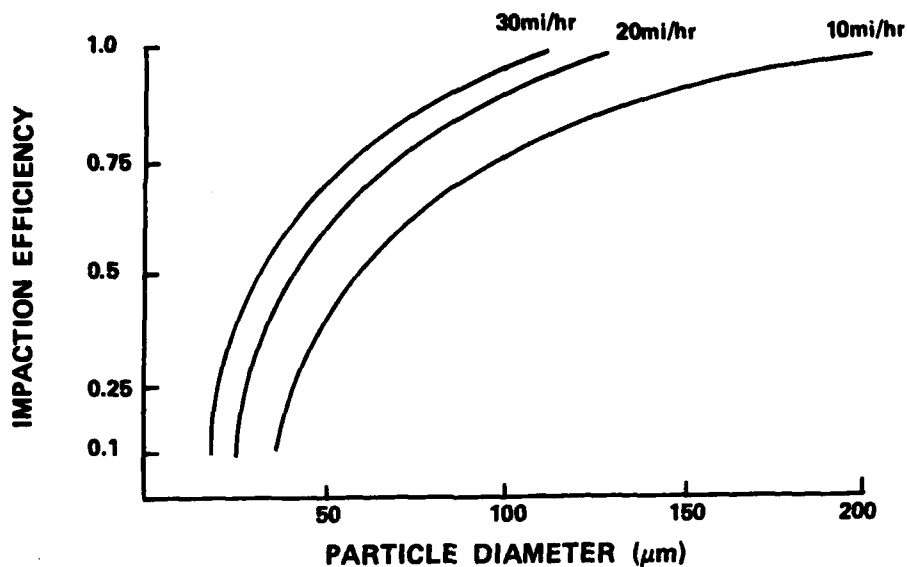


FIGURE 1. Impactation Efficiency vs. Particle Diameter for Spherical Particles Against a Flat Circular Disk (8-inch-diameter lens) at 10, 20, and 30 Miles Per Hour Tank Velocities.

These theoretical impactation efficiencies were then used to compute the mass of aerosol impacted on the tank lens for a given distance traveled through the aerosol, assuming an aerosol concentration of 0.1 gm/m^3 (which is typical for a dense tactical screening smoke).

The results of these computations are summarized in the table. As can be seen, under these conditions the size of aerosol cloud required quickly becomes enormous.

Table I. Distance in Meters a Tank must Travel Through an Aerosol* of the Particle Diameter Shown to Achieve 10.0 gm/m² Deposition Density on an 8-Inch Diameter Lens.

Tank Velocity (mi/hr)	PARTICLE DIAMETER μm			
	25	50	75	100
	meters			
10	insignificant impaction	240	160	128
20	insignificant impaction	160	123	107
30	240	138	111	100

*Assuming an aerosol concentration of 0.1 gm/m³ which is typical of a tactical screening smoke.

III. CONCLUSIONS.

Previous studies on the concept to defeat sighting devices with an airborne optical coating, although not complete, provide sufficient data to assess the desirability of further efforts on such concepts. To be effective, either the munition must be functioned very close to and in front of the optics or a true aerosol cloud must be produced over a fairly large area. Both of these options result in a significant logistic burden when compared with more conventional countermeasures such as high explosives or smoke. Barring a major technical breakthrough, therefore, additional research or development on these concepts does not appear warranted.

APPENDIX

ANNOTATED BIBLIOGRAPHY OF PREVIOUS STUDIES OF THE STICKY AEROSOL CONCEPT

1. Edgewood Arsenal Technical Memorandum, ARCSL-TM-79005. Preliminary Feasibility Study of the 'Sticky Aerosol' Concept, by B. Gerber, W. Cooper. April 1979.

- a. A two week study was conducted for TRADOC in April 1976.
- b. They investigated three classes of material (i.e. absorber, reflector, and scatter (diffuser)).
- c. Laboratory trials were conducted using carefully produced coated slides to measure loss of visual acuity vs. pigmented-coating density (mg/m² uniformly applied to glass). Experiments were conducted with uniform deposits of varying density and therefore optical density.
- d. Limited field trials were conducted using tank gunners and coated slides over their optics. Results are reported in terms of deposition density vs. effect on hitting a target 300 meters away
- e. Conclusions were that a uniform deposit of 2 to 20 gms/m² of reflecting pigment would be required to insure defeat of the gunner.
- f. The practicality of achieving this coverage, the effect of non-uniform coverage, and potential countermeasures were acknowledged but were not subjects in this study.

2. Falcon Industries Contract Report. Technical Feasibility of a New Optical Active Countermeasure Concept, by R. Telley. March 1977 for AMSAA.

- a. Four optical mechanisms were investigated (i.e. absorption, scattering, diffraction, and reflection) using commercially available pigment/vehicle mixtures.
- b. All experiments were conducted in the laboratory using contrast reduction vs. coating density as a measure of effectiveness. Unfortunately, little indirect background light was available, thereby penalizing the materials which scatter or diffract light.
- c. Little work was reported with less than continuous coatings, however, the observation was made that a near continuous film was needed to achieve acceptable results.
- d. An analysis was made of the "On Target Requirements" using a best guess impaction efficiency of 0.1, CW data for downwind dosage vs. source size, and a size distribution of from 10-# to 100-micrometers diameter. They concluded that a possible scenario would be 1-pound payload submunitions functioned at ranges of up to 20 meters from the target. The uncertainty in impaction efficiency is cited as reason to hope that improvements can be made.

e. Falcon concluded that it is technically feasible to coat optics with a pigment which will degrade vision and of the materials tested an absorbing pigment is best. They also stated that many submunitions delivered within 20 meters of a target will provide optimum weaponization performance.

3. Human Engineering Laboratory Technical Memorandum 24-78. The Obscuration of Vision Through Daytime Telescopes by External Coatings: Field Test Results, by C. C. Smyth. August 1978.

a. Four materials were investigated (green dye, clear base, aluminum pigment, and carbon black). The carbon black and aluminum were mixed in equal volume ratios with dimethyl silicone fluid and a xylene solvent. The green dye was a commercially available green paint diluted with clear lacquer. No attempt was made to achieve equal weights of pigment on the test slides.

b. The test slides were sprayed with equal volumes of paint to various percentages of the view port area.

c. Human observers were timed on their ability to acquire randomly presented targets. The pigments were rated in terms of increase in mean acquisition time.

d. The green pigment was found most effective. It was the only sample which gave a significant increase in mean acquisition time at 80% area coverage. The carbon has a significant effect only at 100% area coverage and the aluminum was no better than the clear base even at 100% coverage. It appears that the prepared samples contained insufficient pigment to appreciably affect optical density. The greater effects observed with the green pigments were probably caused by a combination of reduced color contrast and a more dense coating.

e. Human Engineering Laboratory (HEL) concluded: A sticky aerosol used to obscure telescopic vision must cover more than 80% of the scope face to be effective. This is true for the materials and thickness used in slide preparation for this test. The most effective material forms a crystalline structure on the scope face. This material scatters light into the telescope image of the target. However, the molecular weight of such a material may be too high to be incorporated into an aerosol delivery system.

4. MERADCOM Technical Note. Feasibility Study of An Optical Coating Device Barrier Concept, by L. E. Jacobs, P. M. Kerr, undated. Work accomplished in mid-1976.

a. Conducted a design study and experimental evaluation of a directed-spray optical-coating device. The concept was intended for use as an unattended, controllable barrier which temporarily renders a tank's firepower ineffective by spraying a sticky obscuring coating on the optics of the gunner's telescope.

b. The study looked at front-on tank geometry and the spray pattern needed to insure a high probability of coating the optics of a moving tank. Mockups of a T62 tank were built and glass slides used to measure the amount

of obscuration obtained at the gunner's periscope location. Various spray geometries and dispenser locations were tried to optimize coverage.

c. The logistics burden required to achieve the necessary coverage was computed and compared with emplacing a six-strip minefield. The reduction in burden was found to be insignificant.

d. Field tests confirmed the MERADCOM calculations which showed that (1) effective coverage could only be achieved for near normal bearing angle, (2) the spray had to be activated for more than two seconds, and (3) the tank had to be exposed to the spray for a travel distance of 10 meters or greater.

e. The MERADCOM conclusions were: "The effectiveness of the Optical Coating Device is controlled by a very limited set of circumstances. Because of this, the ease of countermeasuring, the limited improvement in logistical burden, and the degradation in disabling characteristics when compared to a minefield, it is recommended that investigation into optical coating techniques be terminated".

5. TRADOC letter (ATCD-CM-A). Coordinated Letter of Agreement (LOA) for an Optical Coating Anti-Armor Obstacle (OCAO). 27 April 1977.

a. Letter comments on draft LOA for an optical coating system being circulated by the Engineer school. It recommends, based on input from various TRADOC staff elements, that the Engineer school consider discontinuing development of the subject LOA.

b. Comments from the TRADOC elements are summarized as follows:

"(1) The LOA made three key, yet questionable, assumptions as to the effectiveness of the OCAO. These assumptions are:

"(a) That a perfect coating of all vehicular lens surfaces, to include recessed lenses, is possible and that once the lenses are coated, vision is impossible. (These assumptions are questioned).

"(b) That no simple countermeasures are available while, in reality, there are many (e.g. spare sights, sight covers, or plastic wrap).

"(c) That the tank is inoperative after the sights are coated, even though the tank with its hatches open can still be driven, its machine guns fired, and its main gun used for area fire.

"(2) Conclusion. The concept described has limited, if any, operational advantages over destructive anti-armor devices that are presently in the field or under development."

6. Personal Conversations with Dr. B. L. Harris, Deputy Director, Chemical Systems Laboratory, Concerning a DDR&E Study of an Optics-Defeating Aerosol Concept in 1965-68 Time Frame (unpublished).

a. The object of this informal paper study was to examine the feasibility of using an aerial-delivered hydrofluoric acid aerosol over enemy antiaircraft sites to etch their optics.

b. Calculations were made of dosage requirements, initial source size needed and munition expenditure required to achieve various levels of incapacitation.

c. The conclusion reached (and this assumed an impaction efficiency of 1) was that the equivalent of saturation bombing was needed to insure success and that the use of an equivalent amount of HE would produce the same effect.

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